



The Motus Wildlife Tracking System

Progress and Detections
in Missouri, Midwest, and
Neotropics



These partners have generously assisted in the growth of the Motus network in Missouri and beyond. Thank you for your support.



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The Boeing Company via
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None of our Missouri Motus installs would've been possible without the knowledge, expertise, and kindness of MDC's Joe Davis.





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Expansion of the Motus Wildlife Tracking Network in Missouri, the Midwest, and Neotropics

Introduction

The Motus Wildlife Tracking System (Motus) is a collaborative research network that uses arrays of automated radio telemetry receivers to study movements of small animals. Motus works using ultra-lightweight radio tags coded to the Motus frequency attached to our smallest species of migratory birds, bats, and even large insects. When a Motus-tagged animal passes within range of any of the nearly 1,300 Motus receivers in the world, the signal of the tag is detected and stored. The beauty of Motus is that regardless of who places receiver stations across a migratory animal's range, all receivers listen on the same radio frequency and detect Motus tags. This



Motus receiver stations consist of antennas and coaxial cables that feed down to a Motus station that receives detection data from Motus-tagged animals that pass by. Mike Wells, USFWS



A cerulean warbler with a Motus tag. Cerulea.org

means that one individual doesn't have to place Motus receivers along an animal's entire migratory route – anyone who places a Motus station in the world contributes to the broader network of receivers for Motus tags to be detected. This collaborative array of receivers across the hemisphere allows researchers to learn more about migration timing, stop-over sites, and wintering locations faster and over broader scales to target conservation efforts and habitat management for some of our most rapidly declining bird species that need targeted conservation through their full annual cycle.

In 2017, when the Missouri Department of Conservation (MDC) began working to broaden the Motus network, the Midwest was largely a “black hole” for Motus coverage with only about 17 receiver stations in the northern Midwest and near the Great Lakes. Over the last four years, word has spread about the potential for Motus, many partnerships have developed, and a lot of hard work has occurred across many states, resulting in a 600% increase in the number of stations since 2018.

This report educates on Motus and its potential to learn more about our migratory birds and bats and outlines progress in Motus station placement in Missouri, the Midwest, and Neotropics. We have also gathered notable bird and bat detections from our Missouri receivers since 2018. MDC proudly supports these collaborative projects across the hemisphere by growing and maintaining a strong Motus network.

Why Motus?

Motus’ collaborative nature appeals to a broad suite of partner agencies and organizations due to its scope, scale, and ability to teach us about our longest-distance migrants. As of November 22, 2021, there are 1,280 active Motus receivers worldwide. The majority of active Motus receivers are located in southeastern Canada, the northeastern U.S., and along the Gulf of Mexico, but the network is growing rapidly (Figure 1). The Northeastern U.S. Motus receiver network has added a significant amount of knowledge on migratory species (Taylor et al. 2017), including information on migration timing, stop-over sites, and other locations that Neotropical migrants and migratory bat species are using throughout the year. New data and publications on these long-distance movements discovered using Motus are

increasing in the last few years with the rapid expansion of the network. These new findings are contributing to regional, national, and international conservation efforts of Motus-tagged species by identifying and targeting conservation efforts in key stop-over habitats during migratory species’ full life cycles.



Figure 1. Locations of active Motus receivers worldwide. Motus.org

Full Annual Cycle Bird Conservation

The Missouri Department of Conservation has supported full annual cycle conservation efforts for migratory landbirds since 2009 and has supported full annual cycle of our migratory waterfowl species for decades. Full annual cycle (FAC) conservation involves working to protect migratory bird species that breed in Missouri when they are beyond our state's borders. Roughly 335 species occur in Missouri in a given year, give or take vagrants and rarities. Of those, 170 species breed in Missouri, and 84 of those leave Missouri in the non-breeding season. Fifty-eight of these birds, or one-third of Missouri-breeding migratory bird species, leave the U.S. in the non-breeding season for up to 8 months of the year. As a conservation community, we cannot ignore the threats that landbirds face when they are beyond

our borders and know that we are doing all we can for bird conservation. In light of the 2019 *Science* article quantifying the net loss of three billion birds (or 29%) of North American birds since 1970 (Rosenberg et al. 2019), we must bring further attention and support to FAC conservation as a vital piece of bird conservation programs.

MDC has proudly supported FAC landbird conservation since 2009 with the creation of the Association of Fish and Wildlife Agencies' Southern Wings program, which coordinates in-country partnerships on the wintering grounds to provide a menu of effective conservation projects across Mexico, Central America, and South America for our long-distance migrant landbirds so state agencies can support FAC conservation work. MDC has been a lead state contributing

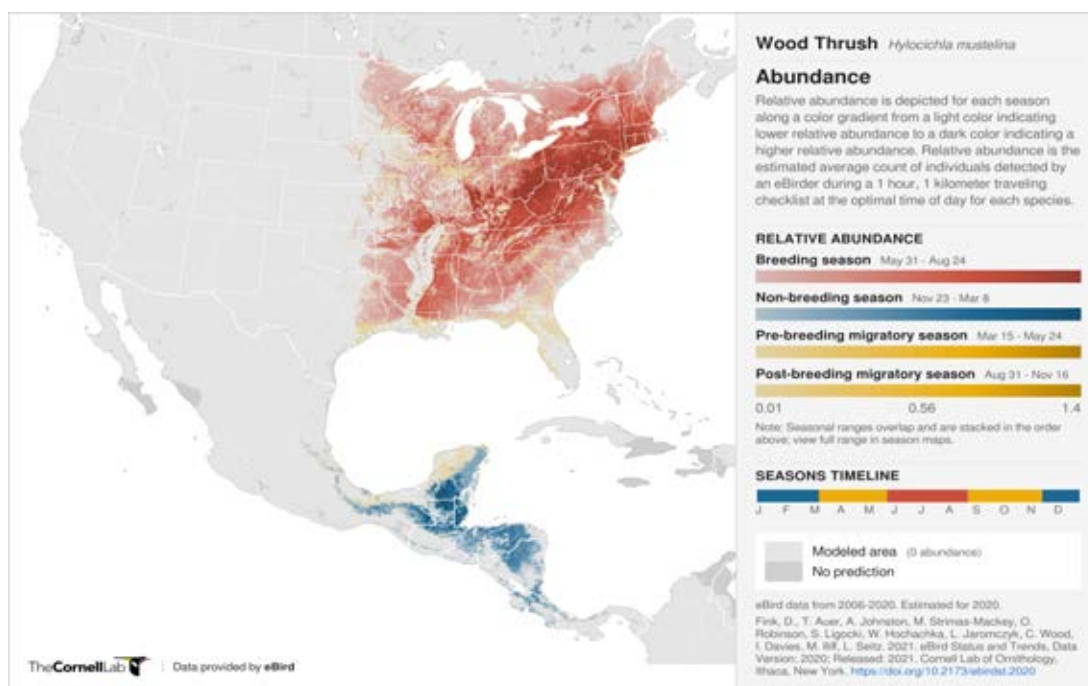


Figure 2. eBird map of a Wood Thrush showing full life-cycle range and abundance.
eBird

to Southern Wings since 2009, and FAC conservation is included in MDC's Comprehensive Conservation Strategy (Missouri's State Wildlife Action Plan).

Motus tracking of birds through migration and beyond identifies timing, stop-over sites, and overwintering locations to inform conservation work for migratory birds throughout the annual cycle. Local tracking efforts of birds both during migration and on the breeding grounds work to target habitat management actions that give us the greatest return on effort for the broadest suites of species, including birds.



A black-throated blue warbler with a Motus tag. Bethany Thurber

Motus Station Placement Progress: Missouri

Missouri's approach to Motus receiver station placement has been to build two east-west latitudinal arrays ("digital fences") of stations with detection diameters as close as possible to maximize detection of Motus-tagged animals as they migrate north-south through the state. This approach was similar to Pennsylvania's northwest-southeast array (Figure 3). The two Missouri arrays have been placed in separate ecoregions of the state in grassland and hardwood forest systems (Figure 3). The northern array lies across the Eastern Tallgrass Prairie Bird Conservation Region of the state (generally along U.S. Hwy 36) and the southern array through

the Central Hardwoods Bird Conservation Region (generally along U.S. Hwy 60). This approach captures the movements of a diversity of migratory species' guilds that use different habitats as they move through the state. Missouri's efforts in placing stations also helped build out the Midwest Migration Network's Strategic Motus Plan, which outlines east-west latitudinal arrays across USFWS Region 3 (Figure 4).

Missouri's first Motus station was placed in October 2018 at MDC Headquarters. Supplies for this station were provided by USFWS Ecological Services in Columbia and was intended to test the functionality of



Figure 3. Pennsylvania's northwest-southeast array of Motus stations in 2018 depict a "digital fence" placement. Missouri is adopting a similar approach with two east-west "digital fences". Motus.org

Motus technology as a pilot before expanding Missouri's Motus network more broadly. In 2019, USFWS awarded MDC and partners St. Louis Zoo and Illinois Natural History Survey (University of Illinois Champaign-Urbana), a Region 3 Migratory Birds Grant (MBJ19), which funded the placement of 14 new stations: six stations along the southern latitudinal "digital fence" array of receivers, two stations located in Saint Louis and managed by the Saint Louis Zoo, four stations in Illinois managed by the Illinois Natural History Survey (University of Illinois Champaign-Urbana), and four stations in Guatemala managed by American Bird Conservancy and local partner Fundación para el Ecodesarrollo y La Conservación (FUNDAECO) on FUNDAECO-owned conservation reserves.

MDC deployed the six southern MBJ19 grant-funded stations in January of 2020 along with two additional stations, bringing the total number of Motus receivers in the state to nine. By the end of October 2020, MDC deployed seven additional stations across the

northern latitudinal, increasing the total number of Motus stations to 16. The Saint Louis Zoo deployed one of their two grant-funded stations a few blocks south of the Zoo in August 2021, and the second station is in progress.

By December 2021, there are 19 active Motus stations in Missouri (Figure 5). Currently, 15 of the MDC managed stations are dual-listening Cellular Tracking Technologies (CTT) SensorStations, which are receivers equipped with two types of antennas to detect Motus tags on two separate frequencies: 166.38 MHz NanoTag™ tags (Lotek Wireless Inc.) and 434 MHz LifeTag™, PowerTag™, and HybridTag™ tags (Cellular Tracking Technologies). Missouri and the Midwest have adapted to these changes in the Motus technology to make receivers as useful as possible to the widest range of tag types and research approaches. The stations at MDC Headquarters and St. Louis Zoo South are equipped with 166.38 MHz antennas only. In 2020, a USFWS Competitive State Wildlife Grant (CSWG) was awarded to MDC and nine other

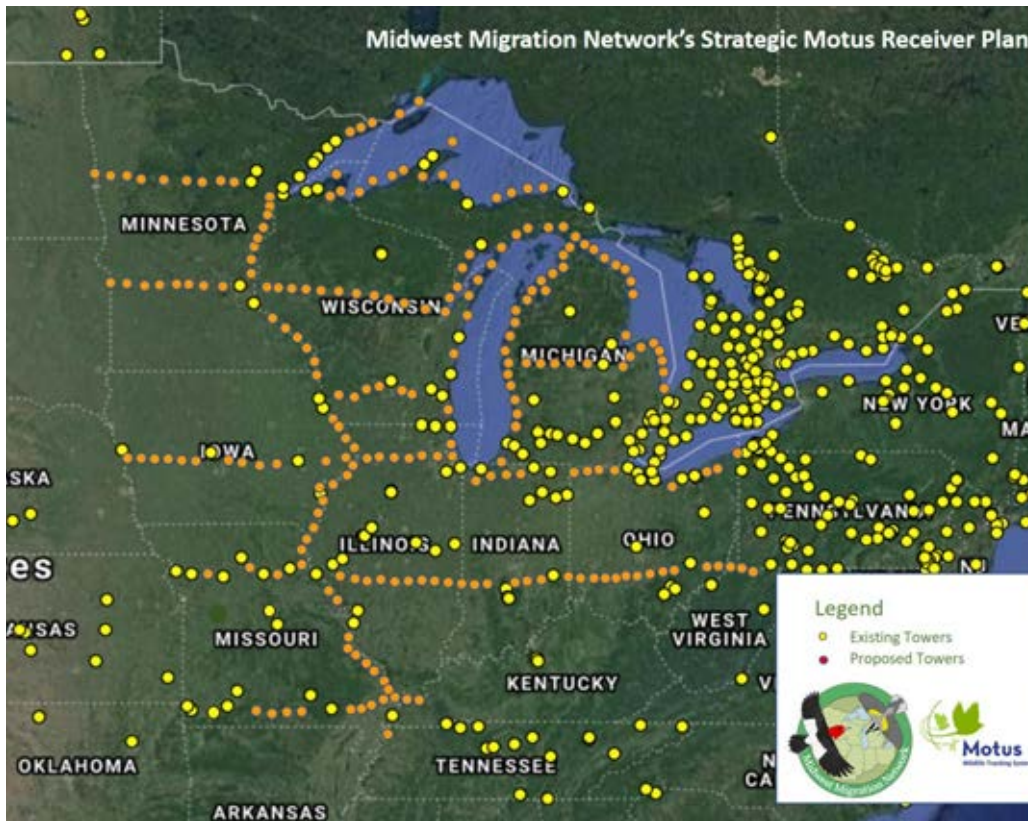


Figure 4. Active (yellow) and proposed (orange) locations of Motus stations in the Midwestern U.S. Midwest Migration Network

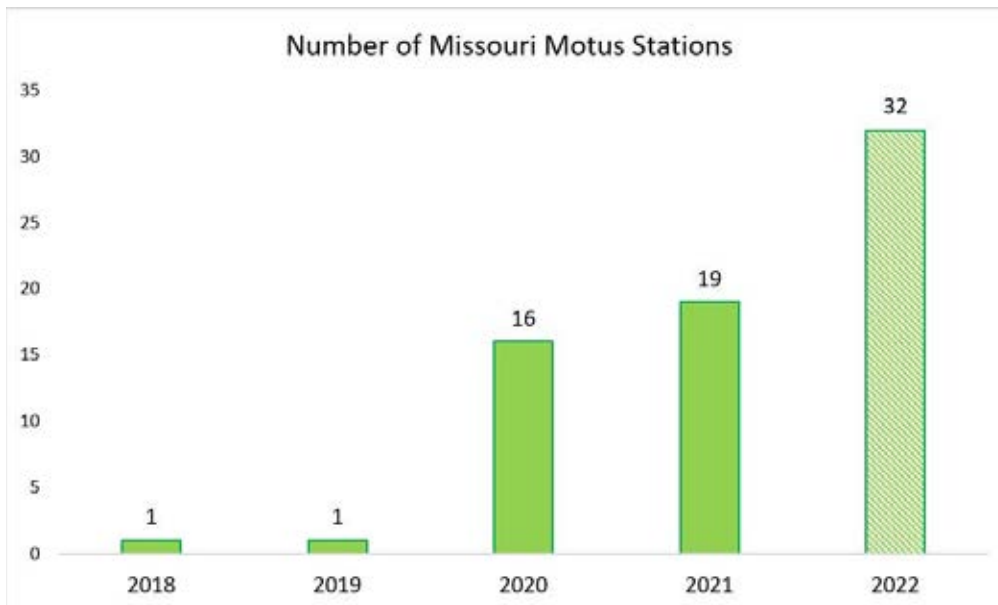


Figure 5. Number of active Motus stations in Missouri since 2018. 13 stations will be added to the network in 2022.

partners to place 59 Motus stations across eight Midwestern states (IA, IN, IL, OH, MI, MN, MO, WI) and three countries (Mexico, Costa Rica, and Colombia). Among other Motus stations and Motus-tracking research projects, this grant funds the addition of six Motus stations to the Missouri landscape in 2022. Additional details on the outcomes of this grant award are discussed in the following sections. With the addition of these six CSWG funded stations, three additional MDC-funded stations, three Missouri Conservation Heritage Foundation-funded stations, and the second St. Louis Zoo grant-funded station, Missouri will have 30 active Motus stations within the next year (Figure 5).

Motus Station Placement Progress: Midwest

Prior to 2020, there was a large gap in the Motus receiver array across the Midwest (Figure 6). There has been tremendous progress in station placement over the past four years. In January 2018 there were 17 Motus stations across the Midwest states of Iowa, Indiana, Illinois, Michigan, Missouri, Minnesota, Ohio, and Wisconsin. Currently, there are 114 stations placed across the Midwest with more planned for deployment in the immediate future.

In 2020, the USFWS awarded a Competitive State Wildlife Grant (CSWG) to collaborators representing the Missouri Department of Conservation (lead state); Iowa Department of Natural Resources (DNR); Indiana DNR; Ohio DNR; Minnesota DNR; Kalamazoo Bird Observatory; Illinois Natural History Survey; University of Maine; SELVA: Investigación para la Conservación en el Neotropico; and National Audubon Society. This grant is funding the placement of 45 new Motus stations across 8 Midwest states, as well as 14 in the Neotropics (Mexico, Costa Rica, and Colombia). In addition, this grant sup-

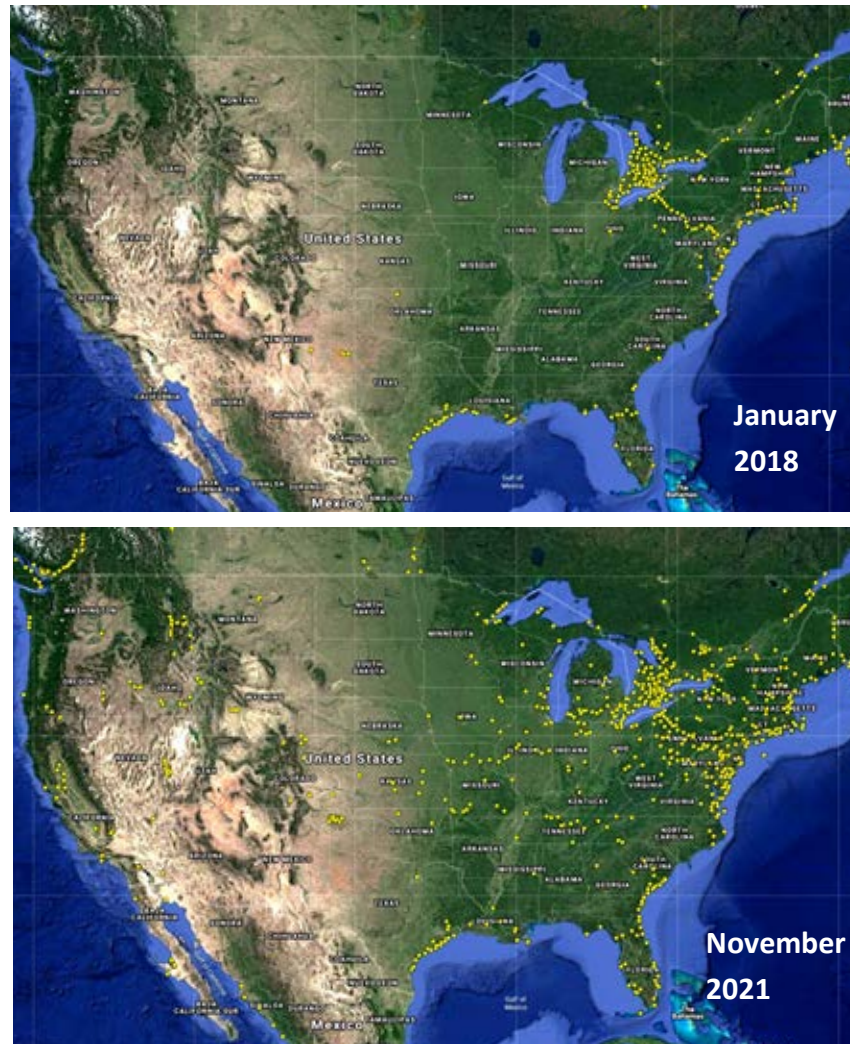


Figure 6. Motus receiver locations across the Midwest in 2018 and 2021. In January 2018 the Midwest had 17 Motus receivers, as of November 2021 this number had increased to 114 receivers. *Motus.org*

ports three Motus- tracking research projects on American Kestrels (*Falco sparverius*), Golden-winged Warblers (*Vermivora chrysoptera*), and Wood Thrush (*Hylocichla mustelina*).

Motus Station Placement Progress: Neotropics

While there has been much progress placing Motus stations in the Neotropics since 2018, there is still a critical need for expansion of the Motus network in this area. In January 2018, there were 20 Motus stations in the Neotropics, and at the end of 2021 there were 50 stations in the Neotropics (Figure 7).

The previously mentioned 2020 CSWG expands the Motus network in the Midwest, but also includes funding for deployment of 14 Motus stations in the Neotropics. Four stations will be placed in Mexico (Yucatan Peninsula), three in Costa Rica, and four in Colombia.

Between grant funding and donations, conservation partners in the Midwest will have helped support the placement of 20 Motus stations in the Neotropics in the last few years.

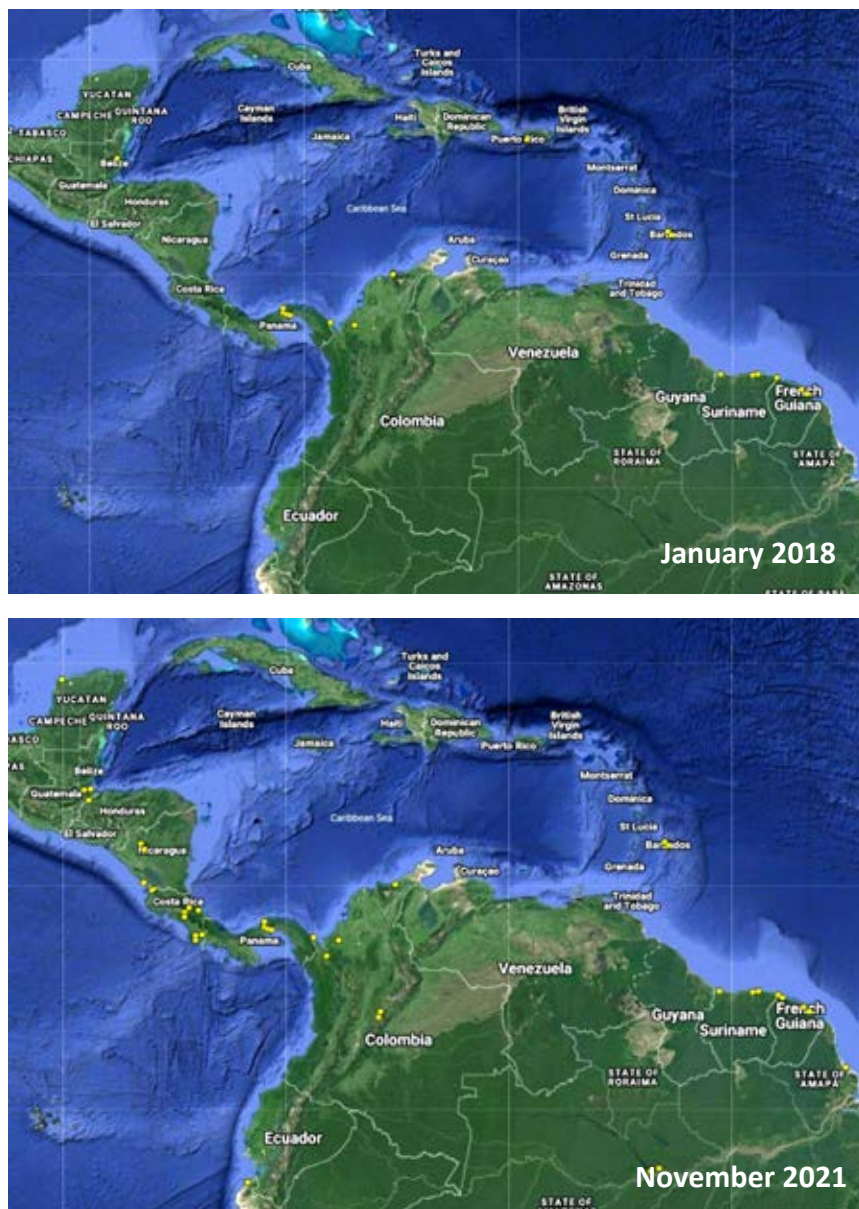


Figure 7. Motus receiver locations in the Neotropics in 2018 and 2021. In January 2018 the Neotropics had 20 Motus receivers, as of November 2021 there are 50 receivers. Motus.org

Missouri Station Detections

Since 2018, Missouri Motus stations have logged 101 total detections, representing 16 species of bird and 1 species of bat (Tables 1-3). The species detected include Common Nighthawk (*Chordeiles minor*), Eastern Whip-poor-will (*Antrostomus vociferus*), Virginia Rail (*Rallus limicola*), Sora (*Porzana carolina*), Semipalmated Sandpiper (*Calidris pusilla*), Stilt Sandpiper (*Calidris himantopus*), Black Tern (*Chlidonia niger*), Common Tern (*Sterna hirundo*), American Kestrel (*Falco sparverius*), Blue Jay (*Cyanocitta cristata*), Barn Swallow (*Hirundo rustica*), Gray Catbird (*Dumetella caro-*

linensis), Swainson's Thrush (*Catharus ustulatus*), American Tree Sparrow (*Spizelloides arborea*), Rusty Blackbird (*Euphagus carolinus*), Mourning Warbler (*Geothlypis philadelphia*), and eastern red bat (*Lasiurus borealis*). Animals detected by Missouri Motus stations were deployed by 19 different projects across the western hemisphere (Figure 8). All but one station in the state have detected Motus tags.



Figure 8. Locations where tags were deployed that were later detected on Missouri Motus stations.

Table 1. Species detected by Missouri Motus stations and number of detections.

Species	# detections	Photos
Common Nighthawk (<i>Chordeiles minor</i>)	4	 CC by 2.0 Julio Molero
Eastern Whip-poor-will (<i>Antrostomus vociferus</i>)	4	 CC by 2.0 Andy Reago
Virginia Rail (<i>Rallus limicola</i>)	1	 CC by 2.0 Andy Reago
Sora (<i>Porzana carolina</i>)	1	 CC by 2.0 Susan Young
Semipalmated Sandpiper (<i>Calidris pusilla</i>)	2	 CC by 2.0 Tom Wilberding
Stilt Sandpiper (<i>Calidris himantopus</i>)	1	 CC by 2.0 Andrew Reding

Table 2. Species detected by Missouri Motus stations and number of detections.


Species	# detections	Photos
Black Tern (<i>Chlidonias niger</i>)	13	 A Black Tern with dark plumage and a white forehead patch is perched on a wooden post. The background is a soft, out-of-focus green. CC by 2.0 Virginia Rivers
Common Tern (<i>Sterna hirundo</i>)	1	 A Common Tern is shown in flight, displaying its white body, dark wings, and a sharp black cap. The background is a clear blue sky. CC by 2.0 Sonia Johnson
American Kestrel (<i>Falco sparverius</i>)	25	 An American Kestrel with a rusty-orange and white speckled pattern is perched on a thin branch. The background is filled with green foliage. CC by 2.0 Kenneth Cole Schneider
Blue Jay (<i>Cyanocitta cristata</i>)	1	 A Blue Jay with its characteristic blue, white, and black feathers is perched on a branch, facing left. The background is a blurred natural setting. CC by 2.0 Karin Lewis
Barn Swallow (<i>Hirundo rustica</i>)	4	 Two Barn Swallows are on a wooden post. One is perched while the other is in flight, showing its dark wings and forked tail. The background is a clear blue sky. CC by 2.0 Doug Greenburg
Gray Catbird (<i>Dumetella carolinensis</i>)	6	 A Gray Catbird is perched on a branch, facing left. It has a grayish-brown body and a white throat. The background is a soft-focus green. CC by 2.0 Dennis Church

Table 3. Species detected by Missouri Motus stations and number of detections.

Species	# detections	Photos
Swainson's Thrush (<i>Catharus ustulatus</i>)	33	 A photograph of a Swainson's Thrush perched on a dark branch. The bird has a greyish-brown back, a white belly, and a yellowish-green throat. The background is dark and out of focus. CC by 2.0 Kelly Colgan Azar
American Tree Sparrow (<i>Spizelloides arborea</i>)	1	 A photograph of an American Tree Sparrow perched on a thin, light-colored branch. The bird has a reddish-brown head, a white throat, and a brown and white striped back. The background is a soft, out-of-focus green. CC by 2.0 Tom Murray
Rusty Blackbird (<i>Euphagus carolinus</i>)	1	 A photograph of a Rusty Blackbird perched on a dark, textured branch. The bird has a dark greyish-black body and a white eye. The background is a soft, out-of-focus green. CC by 2.0 Andy Reago
Mourning Warbler (<i>Geothlypis philadelphia</i>)	2	 A photograph of a Mourning Warbler perched on a dark branch. The bird has a blue-grey head and back, a white throat, and a yellowish-green belly. The background is a soft, out-of-focus green. CC by 2.0 Tom Benson
Eastern Red Bat (<i>Lasiurus borealis</i>)	1	 A photograph of an Eastern Red Bat perched on a branch. The bat has a reddish-brown body and a small, dark face. The background is a soft, out-of-focus green. CC by 2.0 Judy Gallagher

Missouri Motus Station Detections

Missouri Motus stations have detected 100 birds and one bat since 2018. In the following sections, each station is listed by name and we include a brief summary of detections, as well as a table listing all detections for each station. Figure 9 illustrates variation in number of detections by station.

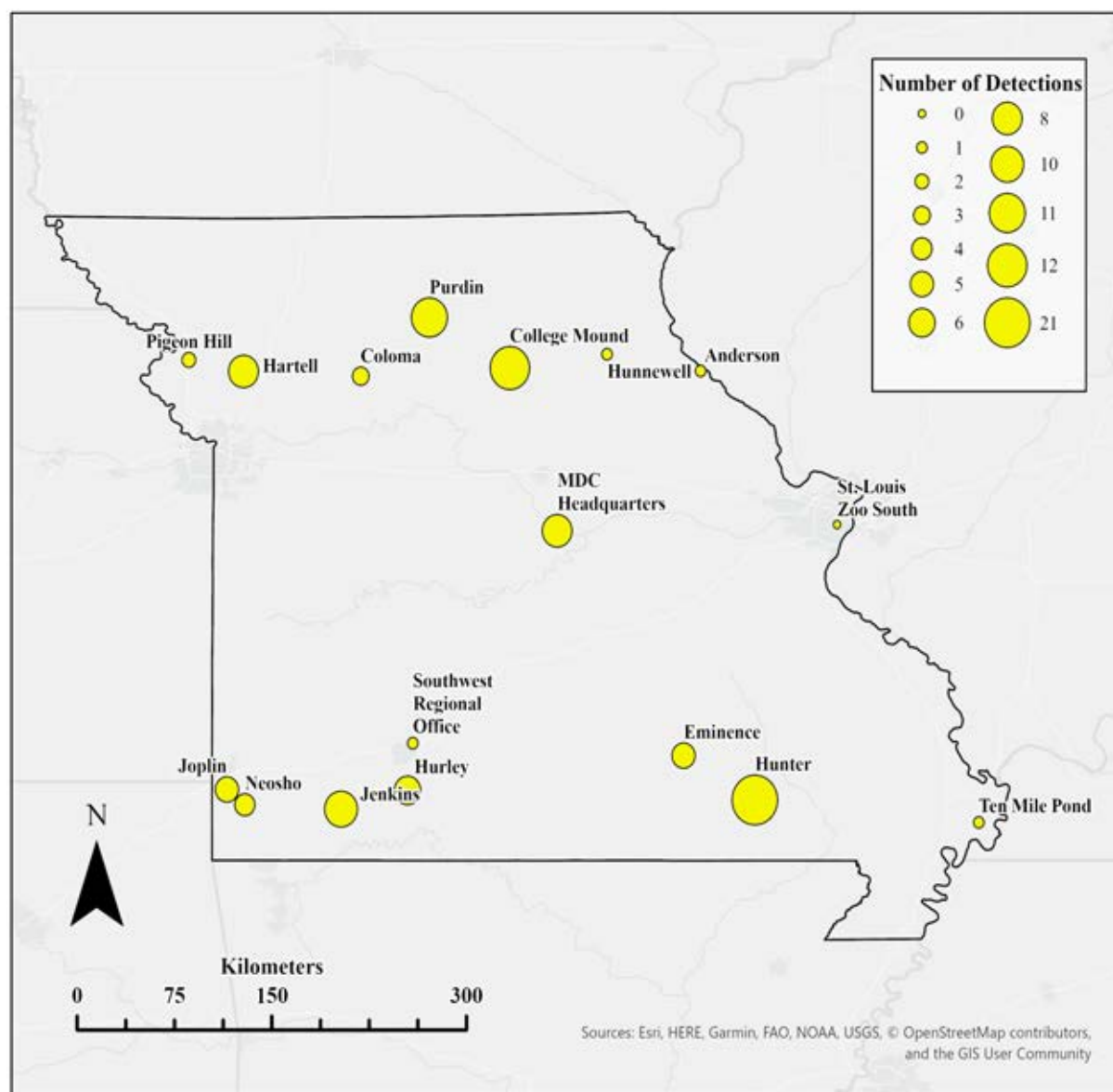


Figure 9. Locations of active Motus stations in Missouri. Marker size represents the number of detections at each station.

MDC Headquarters

The Missouri Department of Conservation (MDC) deployed the first Motus station in Missouri at the Conservation Commission Headquarters in Jefferson City on 12 October 2018. The station at headquarters is equipped with a SensorGnome receiver and 2 166.38 MHz antennas. The station has detected 8 birds. Species detected include Swainson’s Thrush, Semipalmated Sandpiper, and Gray Catbird. Details on detection dates, deployment dates, locations, and projects for the tagged birds can be found below in Table 4.

Table 4. Detections at MDC Headquarters station managed by the Missouri Department of Conservation (MDC), located at the MDC Conservation Commission Headquarters in Jefferson City, MO.

MDC Headquarters			
Detection Date	Species	Deployment Date	Deployment Project
2019-05-07	Swainson's Thrush	2019-04-27	Louisiana Chenier Stopover Habitat
2019-05-21	Semipalmated Sandpiper	2019-05-13	Tulane SESA Stopover
2019-05-22	Swainson's Thrush	2019-05-04	Louisiana Chenier Stopover Habitat
2019-05-24	Swainson's Thrush	2019-05-11	Clive Runnells Mad Island Marsh Preserve
2021-10-02	Swainson's Thrush	2021-09-05	BC Interior Thrushes
2021-10-16	Swainson's Thrush	2021-09-05	BC Interior Thrushes
2021-10-17	Swainson's Thrush	2021-09-03	BC Interior Thrushes
2021-10-30	Gray Catbird	2021-10-02	Clive Runnells Mad Island Marsh Preserve

Ten Mile Pond

The Motus station at Ten Mile Pond Conservation Area, located in Mississippi County, was first activated on 9 January 2020 with a SensorGnome receiver and 2 166.38 MHz antennas. On 20 July 2021, the station was retrofitted with a dual-listening Cellular Tracking Technologies (CTT) receiver and 2 additional antennas set to 434 MHz. The dual-listening receiver detected one tagged bird, a Virginia Rail. Details on detection dates, deployment dates, locations, and projects for the tagged birds can be found in Table 5.

Table 5. Detections at the Ten Mile Pond station. The Missouri Department of Conservation manages the Ten Mile Pond station, located at Ten Mile Pond Conservation Area near Mississippi County, MO.

Ten Mile Pond			
Detection Date	Species	Deployment Date	Deployment Project
2021-10-05	Virginia Rail	2021-05-04	Forbes Biological Station

Hunter

The Hunter station, located at Hunter Towersite, was first activated on 9 January 2020 with a SensorGnome receiver and 4 166.38 MHz antennas, the station was retrofitted with a dual-listening CTT receiver and 2 additional antennas set to 434 MHz on 20 July 2021. The historic SensorGnome receiver detected 13 tags, while the current dual-listening receiver has detected 8 tags. With 21 tag

detections, as of November 2021, the Hunter station has the most detections out of all stations located in Missouri. Species detected by this station include Common Nighthawk, Swainson's Thrush, Eastern Whip-poor-will, Barn Swallow, Black Tern, and Sora. Details on detection dates, deployment dates, locations, and projects for the tagged birds can be found in Table 6.

Table 6. Detections at the Hunter station. The Missouri Department of Conservation manages the Hunter station, located at Hunter Towersite in Hunter, MO.

Hunter			
Detection Date	Species	Deployment Date	Deployment Project
2020-09-03	Common Nighthawk	2019-06-18	Intermountain West Collaboration - Birds
2020-09-18	Swainson's Thrush	2020-08-20	Intermountain West Collaborative - UM Birds
2020-09-24	Swainson's Thrush	2020-08-26	Intermountain West Collaborative - UM Birds
2020-09-26	Swainson's Thrush	2020-08-31	Intermountain West Collaborative - UM Birds
2020-09-29	Swainson's Thrush	2020-09-02	BC Interior Thrushes
2020-10-03	Swainson's Thrush	2020-09-06	BC Interior Thrushes
2020-10-04	Swainson's Thrush	2020-09-01	BC Interior Thrushes
2020-10-13	Eastern Whip-poor-will	2020-05-21	Common Nighthawk / Eastern Whip-poor-will
2020-10-17	Swainson's Thrush	2020-09-15	Intermountain West Collaborative - UM Birds
2021-04-08	Eastern Whip-poor-will	2020-05-10	Common Nighthawk / Eastern Whip-poor-will
2021-04-27	Eastern Whip-poor-will	2020-05-10	Common Nighthawk / Eastern Whip-poor-will
2021-05-07	Barn Swallow	2021-01-20	Saskatchewan Passerine Ecology
2021-06-05	Barn Swallow	2021-03-15	Saskatchewan Passerine Ecology
2021-08-09	Black Tern	2021-06-17	Black Tern Dispersal - Saskatchewan
2021-09-06	Common Nighthawk	2021-08-11	Intermountain West Collaboration - Birds
2021-09-09	Swainson's Thrush	2021-08-24	Intermountain West Collaborative - UM Birds
2021-10-05	Sora	2021-10-03	Forbes Biological Station
2021-10-05	Swainson's Thrush	2021-08-24	Intermountain West Collaborative - UM Birds
2021-10-05	Swainson's Thrush	2021-08-29	BC Interior Thrushes
2021-10-17	Swainson's Thrush	2021-09-06	BC Interior Thrushes
2021-11-02	Swainson's Thrush	2021-09-07	BC Interior Thrushes

Eminence

The Eminence station, located on the Angeline Conservation Area, was first activated on 9 January 2020, and was equipped with a SensorGnome receiver and 2 166.38 MHz antennas. The station was deactivated on 23 June 2021. On 18 July 2021, the station was retrofitted with a dual-listening CTT receiver and 2 additional antennas set to 434 MHz,

then reactivated. The historic SensorGnome receiver had 1 detection of a Swainson's Thrush, while the current station has detected 4 tags. Species detected by the currently active CTT receiver include Swainson's Thrush and Black Tern. Details on detection dates, deployment dates, locations, and projects for the tagged birds can be found in Table 7.

Table 7. Detections at the Eminence station. The Missouri Department of Conservation manages the Eminence station, located at Angeline Conservation Area in Eminence, MO.

Eminence			
Detection Date	Species	Deployment Date	Deployment Project
2020-10-17	Swainson's Thrush	2020-09-15	Intermountain West Collaborative - UM Birds
2021-07-25	Black Tern	2021-07-07	Black Tern Dispersal - Saskatchewan
2021-08-23	Black Tern	2021-07-03	Black Tern Dispersal - Saskatchewan
2021-09-12	Swainson's Thrush	2020-08-20	Intermountain West Collaborative - UM Birds
2021-09-24	Swainson's Thrush	2020-09-06	BC Interior Thrushes

Springfield/Southwest Regional Office

The Motus station in Springfield, Missouri was first activated on 14 January 2020, and was equipped with a SensorGnome receiver and 2 166.38 MHz antennas. On 12 July 2021, the station was retrofitted with a dual-listening CTT receiver and 2 additional antennas set to 434 MHz. The historic Sen-

sorGnome receiver did not detect any tags. The current CTT receiver has detected 1 tagged bird, a Swainson's Thrush. Details on the detection date, deployment date, location of deployment, and project for the tagged bird can be found in Table 8.

Table 8. Detections at the Missouri Department of Conservation (MDC) Springfield/Southwest Regional Office station. MDC manages the Springfield/Southwest Regional Office station, located at the MDC Southwest Regional Office in Springfield, MO.

Springfield/Southwest Regional Office			
Detection Date	Species	Deployment Date	Deployment Project
2021-10-02	Swainson's Thrush	2021-08-28	BC Interior Thrushes

Neosho

The Motus station in Neosho, located at the MDC Neosho District Headquarters, was first activated on 14 January 2020, and was equipped with a SensorGnome receiver and 2 166.38 MHz antennas. On 12 July 2021, the station was retrofitted with a dual-listening CTT receiver and 2 additional antennas set to 434 MHz. The historic SensorGnome receiver had 3 detections including Swainson’s Thrushes and a Gray Catbird. The current receiver has also detected 3 tags. Species detected by the current receiver include Gray Catbird, Barn Swallow, and American Kestrel. Details on detection dates, deployment dates, locations, and projects for the tagged birds can be found in Table 9.

Table 9. Detections at the Neosho station. The Missouri Department of Conservation (MDC) manages the Neosho station, located at the MDC Neosho District Headquarters in Neosho, MO.

Neosho			
Detection Date	Species	Deployment Date	Deployment Project
2020-09-03	Swainson's Thrush	2019-08-26	Intermountain West Collaborative - UM Birds
2020-09-28	Swainson's Thrush	2020-09-09	Intermountain West Collaborative - UM Birds
2020-09-29	Gray Catbird	2020-09-01	Intermountain West Collaborative - UM Birds
2020-10-13	Gray Catbird	2020-09-04	Intermountain West Collaborative - UM Birds
2021-06-27	Barn Swallow	2021-04-27	Saskatchewan Passerine Ecology
2021-09-23	American Kestrel	2021-06-02	AMKE Research Minnesota

Joplin

The Joplin station, located at the Joplin Towersite, was first activated on 14 January 2020, and was equipped with a SensorGnome receiver and 2 166.38 MHz antennas. On 12 July 2021, the station was retrofitted with a dual-listening CTT receiver and 2 additional antennas set to 434 MHz. The historic SensorGnome receiver had 2 detections including a Swainson’s Thrush and a Gray Catbird. The current receiver has detected 3 tags. Species detected by the current receiver include Gray Catbird and Black Tern. Details on detection dates, deployment dates, locations, and projects for the tagged birds can be found in Table 10.

Table 10. Detections at the Joplin station. The Missouri Department of Conservation manages the Joplin station, located at the Joplin Towersite south of Joplin, MO.

Joplin			
Detection Date	Species	Deployment Date	Deployment Project
2020-09-03	Swainson's Thrush	2019-08-26	Intermountain West Collaborative - UM Birds
2020-10-13	Gray Catbird	2020-09-04	Intermountain West Collaborative - UM Birds
2021-08-06	Black Tern	2021-06-28	Black Tern Dispersal - Saskatchewan
2021-08-30	Black Tern	2021-07-19	Black Tern Dispersal - Saskatchewan
2021-09-22	Gray Catbird	2020-08-27	Intermountain West Collaborative - UM Birds

Jenkins

The Jenkins station located northwest of Jenkins, MO, was first activated on 14 January 2020, and was equipped with a SensorGnome receiver and 2 166.38 MHz antennas. On 12 July 2021, the station was retrofitted with a dual-listening CTT receiver and 2 additional antennas set to 434 MHz. The historic SensorGnome receiver had 3 detections including a Mourning Warbler, a Common Nighthawk, and an Eastern Whip-poor-will. The current receiver has detected 7 birds, all of which were American Kestrels. Details on detection dates, deployment dates, locations, and projects for the tagged birds can be found in Table 11.

Table 11. Detections at the Jenkins station. The Missouri Department of Conservation manages the Jenkins station, located northwest of Jenkins, MO.

Jenkins			
Detection Date	Species	Deployment Date	Deployment Project
2020-05-24	Mourning Warbler	2020-04-15	SELVA Colombia
2020-09-24	Common Nighthawk	2020-08-23	Intermountain West Collaboration - Birds
2020-10-16	Eastern Whip-poor-will	2020-05-10	Common Nighthawk / Eastern Whip-poor-will
2021-09-05	American Kestrel	2021-05-28	AMKE Research Minnesota
2021-09-22	American Kestrel	2021-06-07	AMKE Research Minnesota
2021-09-30	American Kestrel	2021-06-09	AMKE Research Minnesota
2021-10-04	American Kestrel	2021-06-03	AMKE Research Minnesota
2021-10-05	American Kestrel	2021-06-02	AMKE Research Minnesota
2021-10-05	American Kestrel	2021-05-13	AMKE Research Minnesota
2021-10-12	American Kestrel	2021-06-02	AMKE Research Minnesota

Hurley

The Hurley station located northeast of Highlandville, MO, was first activated on 14 January 2020, and was equipped with a SensorGnome receiver and 2 166.38 MHz antennas. On 12 July 2021, the station was retrofitted with a dual-listening CTT receiver and 2 additional antennas set to 434 MHz. The historic SensorGnome receiver had 3 detec-

tions including a Semipalmated Sandpiper, a Mourning Warbler, and a Gray Catbird. The current receiver has detected 3 birds including Black Terns and an American Kestrel. Details on detection dates, deployment dates, locations, and projects for the tagged birds can be found in Table 12.

Table 12. Detections at the Hurley station. The Missouri Department of Conservation manages the Hurley station, located northeast of Highlandville, MO.

Hurley			
Detection Date	Species	Deployment Date	Deployment Project
2020-05-16	Semipalmated Sandpiper	2020-03-17	Brazil Non-Breeding Shorebirds
2020-05-24	Mourning Warbler	2020-04-15	SELVA Colombia
2020-09-24	Gray Catbird	2020-08-28	Intermountain West Collaborative - UM Birds
2021-07-23	Black Tern	2021-06-22	Black Tern Dispersal - Saskatchewan
2021-07-25	Black Tern	2021-06-24	Black Tern Dispersal - Saskatchewan
2021-10-29	American Kestrel	2021-06-07	AMKE Research Minnesota

Pigeon Hill

The Pigeon Hill station, located on the Pigeon Hill Conservation Area in St Joseph, was activated on 21 October 2020 with a dual-listening CTT receiver, 4 166.38 MHz antennas, and 2 434 MHz antennas. The

station has detected 2 tags, both belonging to American Kestrels. Details on detection dates, deployment dates, locations, and projects for the tagged birds can be found in Table 13.

Table 13. Detections at the Pigeon Hill station. The Missouri Department of Conservation manages the Pigeon Hill station, located at the Pigeon Hill Conservation Area near St Joseph, MO.

Pigeon Hill			
Detection Date	Species	Deployment Date	Deployment Project
2021-10-03	American Kestrel	2021-06-09	AMKE Research Minnesota
2021-10-04	American Kestrel	2021-06-09	AMKE Research Minnesota

Hartell

The Hartell station, located on the Ronald and Maude Hartell Conservation Area northeast of Plattsburg, was activated on 21 October 2020 with a dual-listening CTT receiver, 2 166.38 MHz antennas, and 2 434 MHz antennas. The station has de-

tected 8 tags. Species detected include Blue Jay, Common Tern, Black Tern, and American Kestrel. Details on detection dates, deployment dates, locations, and projects for the tagged birds can be found in Table 14.

Table 14. Detections at the Hartell station. The Missouri Department of Conservation manages the Hartell station, located on the Ronald and Maude Hartell Conservation Area northeast of Plattsburg, MO.

Hartell			
Detection Date	Species	Deployment Date	Deployment Project
2020-12-06	Blue Jay	2020-11-05	Ohio State University
2021-07-23	Black Tern	2021-06-22	Black Tern Dispersal - Saskatchewan
2021-07-25	Black Tern	2021-06-24	Black Tern Dispersal - Saskatchewan
2021-08-01	American Kestrel	2021-06-05	AMKE Research Minnesota
2021-08-06	Black Tern	2021-06-28	Black Tern Dispersal - Saskatchewan
2021-08-29	Common Tern	2021-06-15	Poplar Island Restoration Site - Common Terns
2021-10-03	American Kestrel	2021-06-09	AMKE Research Minnesota
2021-10-04	American Kestrel	2021-06-09	AMKE Research Minnesota

Coloma

The Coloma station, located on the Bunch Hollow Conservation Area in Carroll County, was activated on 21 October 2020 with a dual-listening CTT receiver, 2 166.38 MHz antennas, and 2 434MHz antennas. The station has detected 3 tags. Species detected include

eastern red bat and Swainson’s Thrush. Details on detection dates, deployment dates, locations, and projects for the tagged animals can be found in Table 15.

Table 15. Detections from the Coloma station. The Missouri Department of Conservation manages the Coloma station, located on the Bunch Hollow Conservation Area in Carroll County, MO.

Coloma			
Detection Date	Species	Deployment Date	Deployment Project
2021-08-19	Eastern Red Bat	2021-08-05	Virginia Eastern Red Bats
2021-09-28	Swainson's Thrush	2021-08-30	BC Interior Thrushes
2021-10-02	Swainson's Thrush	2021-09-05	BC Interior Thrushes

Purdin

The Purdin station, located near Purdin, was activated on 21 October 2020 with a dual-listening CTT receiver, 2 166.38 MHz antennas, and 2 434 MHz antennas. The station has detected 11 tags. Species detected include Stilt Sandpiper, Black Tern,

Common Nighthawk, Swainson’s Thrush, and American Kestrel. Details on detection dates, deployment dates, locations, and projects for the tagged birds can be found in Table 16.

Table 16. Detections at the Purdin station. The Missouri Department of Conservation manages the Purdin station, located near Purdin, MO.

Purdin			
Detection Date	Species	Deployment Date	Deployment Project
2021-07-16	Stilt Sandpiper	2021-06-25	Nol - Churchill Shorebirds
2021-08-09	Black Tern	2021-06-17	Black Tern Dispersal - Saskatchewan
2021-08-22	Black Tern	2021-07-03	Black Tern Dispersal - Saskatchewan
2021-09-04	Common Nighthawk	2021-07-14	Intermountain West Collaboration - Birds
2021-09-08	Swainson's Thrush	2021-08-28	BC Interior Thrushes
2021-09-15	Swainson's Thrush	2021-08-25	Intermountain West Collaborative - UM Birds
2021-09-15	Swainson's Thrush	2020-09-01	BC Interior Thrushes
2021-09-18	American Kestrel	2021-06-07	AMKE Research Minnesota
2021-09-22	American Kestrel	2021-06-02	AMKE Research Minnesota
2021-09-22	American Kestrel	2021-06-02	AMKE Research Minnesota
2021-10-03	American Kestrel	2021-06-03	AMKE Research Minnesota

College Mound

The College Mound station, located near College Mound, was activated on 22 October 2020 with a dual-listening CTT receiver, 4 166.38 MHz antennas, and 2 434 MHz antennas. The station has detected 12 tags. Species detected include Rusty

Blackbird, American Tree Sparrow, Barn Swallow, Black Tern, American Kestrel, and Swainson’s Thrush. Details on detection dates, deployment dates, locations, and projects for the tagged birds can be found in Table 17.

Table 17. Detections at the College Mound station. The Missouri Department of Conservation manages the College Mound station, located near College Mound, MO.

College Mound			
Detection Date	Species	Deployment Date	Deployment Project
2021-01-19	Rusty Blackbird	2020-10-08	Lake Superior Migration
2021-03-10	American Tree Sparrow	2020-04-02	American Tree Sparrows - Ontario
2021-08-11	Barn Swallow	2021-03-16	Saskatchewan Passerine Ecology
2021-08-23	Black Tern	2021-07-03	Black Tern Dispersal - Saskatchewan
2021-09-01	American Kestrel	2021-05-28	AMKE Research Minnesota
2021-09-08	Swainson's Thrush	2021-08-28	BC Interior Thrushes
2021-09-15	Swainson's Thrush	2020-09-01	BC Interior Thrushes
2021-09-21	Swainson's Thrush	2021-08-31	BC Interior Thrushes
2021-09-25	American Kestrel	2021-06-09	AMKE Research Minnesota
2021-10-04	American Kestrel	2021-05-28	AMKE Research Minnesota
2021-10-04	American Kestrel	2021-06-03	AMKE Research Minnesota
2021-10-04	American Kestrel	2021-06-02	AMKE Research Minnesota

Hunnewell

The Hunnewell station, located on the Hunnewell Lake Conservation Area in Shelby County, was activated on 22 October 2020 with a dual-listening CTT receiver, 2 166.38 MHz antennas, and 2 434 MHz antennas. The station has detected 1 tagged bird, an American Kestrel. Details on detection dates, deployment dates, locations, and projects for the tagged bird can be found in Table 18.

Table 18. Detections from the Hunnewell station. The Missouri Department of Conservation manages the Hunnewell station, located on the Hunnewell Lake Conservation Area in Shelby County, MO.

Hunnewell			
Detection Date	Species	Deployment Date	Deployment Project
2021-09-01	American Kestrel	2021-05-28	AMKE Research Minnesota

Anderson

The Anderson station, located on the Edward Anderson Conservation Area southeast of Saverton, was activated on 27 October 2020 with a dual-listening CTT receiver, 4 166.38 MHz antennas, and 2 434 MHz antennas. The station has detected 1 tagged bird, an American Kestrel. Details on detection dates, deployment dates, locations, and projects for the tagged bird can be found in Table 19.

Table 19. Detections from the Anderson station. The Missouri Department of Conservation manages the Anderson station, located on the Edward Anderson Conservation Area southeast of Saverton, MO.

Anderson			
Detection Date	Species	Deployment Date	Deployment Project
2021-03-08	American Kestrel	2020-07-30	AMKE Research Minnesota

St. Louis Zoo South

The St. Louis Zoo South station, located a few blocks south of the zoo, was activated on 3 August 2021 with a CTT receiver and 2 166.38 MHz antennas. The station is managed by the Saint Louis Zoo. The most recent data upload by this station was 26 August 2021, there have not yet been any detections. A second Zoo-managed Motus station will be placed in the St. Louis area in coming months.

Audubon Center at Riverlands

A station was recently installed at the Audubon Center at Riverlands, located in West Alton, Missouri on the Mississippi River. This dual-listening station was activated on 1 December 2021 with a dual-listening CTT receiver, 4 166.38 MHz antennas, and 4 434 MHz antennas. The station was funded by a St. Louis Audubon Cathleen Creley Memorial Conservation Grant and is managed by staff at the Audubon Center. The station has not yet logged any detections, but we are hopeful for this station's future detections in a prime migratory pathway.

Columbia

Our most recent Motus station was installed in Columbia at the Waters-Moss Memorial Wildlife Area near the city's center and was activated on 30 December 2021 with a dual-listening CTT receiver, 4 166.38 MHz antennas, and 4 434 MHz antennas. The station was funded by the Columbia Audubon Society in memory of Brad Jacobs, retired MDC state ornithologist and passionate proponent and educator of full life-cycle conservation of migratory birds.



Eastern red bat equipped with a Motus tag.

Brock Fenton

Notable Detections

Several notable detections have been recorded by Missouri Motus stations. These noteworthy detections include species of conservation concern, long detection/stopover times, “recaptures”/multiple detections within the state, and numerous detections for Motus projects.

Seven bird species detected by Missouri Motus stations were included on the Continental Watchlist generated by Partners in Flight (PIF). Several species detected are listed as common birds in steep decline (CBSD) including American Tree Sparrow, Black Tern, Common Nighthawk, Common Tern, and Rusty Blackbird. A few species detected by Missouri Motus stations are listed as PIF “D” Yellow Watch List (declining populations) species including Eastern Whip-poor-will and Semipalmated Sandpiper. Monitoring and continuing research of these species provides crucial information for conservation efforts, and the expanding Missouri Motus network provides necessary infrastructure to support such projects.

Detection times for tagged birds and bats have ranged from as short as 10 seconds to over 8 hours. Four tagged birds have stayed within range of a station for an hour or more, including two American Kestrels, a Common Nighthawk, and a Swainson’s Thrush. The Jenkins and Eminence stations both have an average

detection time of over one hour, Jenkins station has an average detection time of 64.7 minutes and Eminence station an average of 103.8 minutes.



Figure 10. Location tracks for a Black Tern from the Black Tern Dispersal—Saskatchewan project. The bird was deployed with a Motus tag in Saskatchewan in July 2021 and detected by three Motus stations in Missouri in August 2021. Motus.org

Over one in four birds detected by Missouri Motus stations were detected at multiple stations within the state at least once. One noteworthy multi-detection is a Swainson's Thrush that was tagged by Intermountain West Collaborative – UM, which has been detected twice in Missouri, with detections over a year apart and at two separate stations. The bird was first detected at the Hunter station in September 2020 and later detected at the Eminence station in September of 2021 (Figure 11). Although 38% of birds have been detected multiple times within the state, most have not, which may indicate that there is a need to fill in gaps in the northern and southern latitudinal “digital fences” to increase detection probability during migration. Also,

many of the batteries on the Motus tags deployed are weight-limited are too small for long-lasting batteries that last multiple seasons.

Four Motus projects have >10 detections of tags at Missouri Motus stations. These projects include AMKE research MN #332, Black Tern Dispersal – Saskatchewan #359, Intermountain West Collaborative – UM birds #352, and BC Interior Thrushes #280. In total, Missouri Motus stations have detected birds and bats from 19 different Motus projects.

One final notable detection is that of an eastern red bat deployed in New Jersey by the Motus project Virginia Eastern Red Bats #167.



Figure 11. Location tracks for a Swainson's Thrush from the Intermountain West Collaborative—UM birds project. The bird was deployed with a Motus tag in Montana in August 2020 and detected by two Motus stations in Missouri a year apart. The bird was first detected by the Hunter station in September 2020 and then by the Eminence station in September 2021. Motus.org

Motus Resources to Learn More

Motus Wildlife Tracking System

motus.org

- * Explore Motus projects, tags, and receiver data.
- * Learn about active projects and read recent publications.
- * Access Motus Guides for deploying receiver stations, tags, and analyzing and visualizing data.

Midwest Migration Network

midwestmigrationnetwork.org

- * Keep up to date with the latest Motus news in the Midwest.
- * Connect and collaborate with other professionals working with Motus in the Midwest.

Motus: Primer and Progress in Missouri, the Midwest, and Neotropics Recorded Webinar

[Search for “YouTube Missouri River Bird Observatory Motus Primer”](#)

- * A 45-minute recorded presentation by MDC Ornithologist and Midwest Regional Motus Coordinator Sarah Kendrick on an intro to wildlife tracking, the Motus network, and Motus expansion and progress covered in this report



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- For an up-to-date list of popular and scientific articles on Motus projects, visit motus.org/data/publications.